Balancing of COD, TSS and NO3-N loads in an urban streams by high resolution online monitoring

Équilibrage des charges de DCO, TSS et NO3-N dans les rejets urbains par une surveillance en ligne à haute fréquence

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RÉSUMÉ

Les petits cours d'eau urbains sont souvent les récepteurs des systèmes de drainage des eaux pluviales, alors que les eaux sont soumises à des impacts hydrauliques et matériels. Outre la mesure de la concentration pure, la prise en compte du rejet (produit du déversement et de la concentration) est particulièrement intéressante, car on peut comparer par équilibrage des apports urbains et naturels.

La présence de capteurs en ligne permet d'équiper deux points de mesure d'une mesure simultanée des nutriments et du débit. La campagne de mesure est axée sur l'enregistrement des apports urbains, c'est pourquoi les points de mesure étaient situés à la limite du système du bassin versant urbain. Grâce à la haute résolution temporelle (15 min), il a été possible de montrer l'influence des épisodes de pluie sur les masses d'eau. Les variations diurnes et les phénomènes particuliers étaient ainsi visibles. Pour détecter les paramètres dissous et particulaires, des capteurs UV-VIS sont principalement utilisés, lesquels ont été complétés par des paramètres physiques. Grâce à l'enregistrement à haute résolution temporelle, il est également possible de déterminer la durée de l'impact nocif, ce qui représente un avantage significatif par rapport à l'échantillonnage.

ABSTRACT

Small urban stream are often recipients of stormwater drainage systems, while the waters are stressed by hydraulic and material impacts. In addition to pure concentration measurement, the consideration of the load (product of discharge and concentration) is particularly interesting, since by balancing urban and natural entries can be compared.

The availability of online sensors makes it possible to equip two measuring points with simultaneous nutrient and flow measurement. The focus of the measurement campaign is on the recording of urban inputs, therefore the measurement points were located at the system boundary of the urban catchment. Due to the high temporal resolution (15 min) it was possible to show the influence of rain events on the waterbodies. This made both diurnal variations and special events visible. For the detection of dissolved and particulate parameters UV-VIS sensors are mainly used, which were supplemented by physical parameters. Due to the temporally high-resolution recording, it is also possible to consider the harmful duration, which represents a significant gain over sampling.

KEYWORDS

(loads, online monitoring, urban stream, water quality, WFD)

INTRUDUCTION

Online measurement systems gives the opportunity of a high temporal resolution (Benisch *et al.* 2017). Separation systems are characterized by numerous outflows whose influence is superimposed on the flowing water. Therefore, it is not possible to monitor each individual initiation. Instead, the cumulative effect on the stream should be investigated. According to the WFD most of these receiving waters are report required waterbodies, therefore these waters are subject to special requirements with regard to the physical-chemical condition (WFD 2000). High-resolution monitoring (every 15 min) offers the possibility of appropriate approaches, especially if the current measures do not lead to an improvement of the ecological status.

1. METHODS

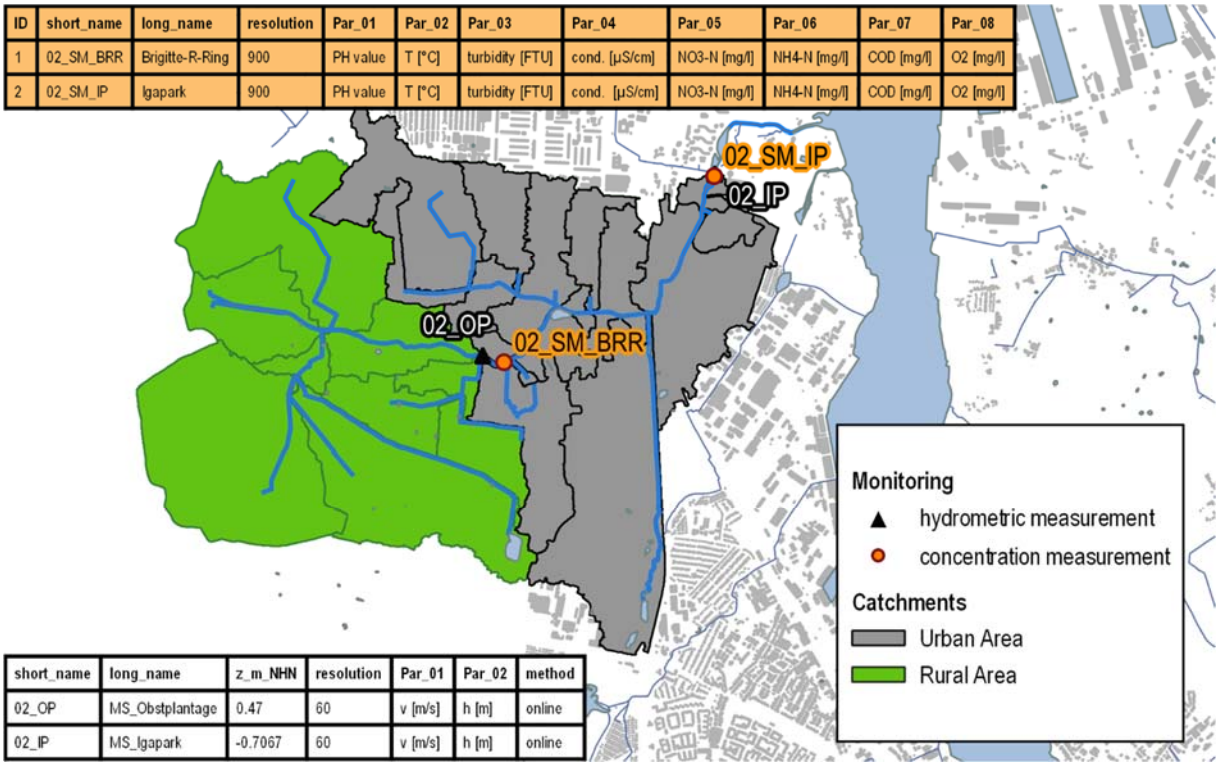
1.1 Continuous Measurements (online)

The focus of the monitoring was on the quantification of the urban-produced pollution, therefore two sites were set up at the border of the urban area to record the rural base load and the total load of the catchment area separately for following key parameters:

- COD - chemical oxygen demand (UV-VIS 220-720nm / Spectro::lyser)
- NH_3-N - ammonia nitrogen
- TSS - total suspended solids)

To better evaluate the context, further material concentrations and usual physical parameters were recorded simultaneously (Figure 1).

ID	short_name	long_name	resolution	Par_01	Par_02	Par_03	Par_04	Par_05	Par_06	Par_07	Par_08
1	02_SM_BRR	Brigitte-R-Ring	900	PH value	T [°C]	turbidity [FTU]	cond. [µS/cm]	NO3-N [mg/l]	NH4-N [mg/l]	COD [mg/l]	O2 [mg/l]
2	02_SM_IP	Igapark	900	PH value	T [°C]	turbidity [FTU]	cond. [µS/cm]	NO3-N [mg/l]	NH4-N [mg/l]	COD [mg/l]	O2 [mg/l]



short_name	long_name	z_m_NHN	resolution	Par_01	Par_02	method
02_OP	MS_Obstplantage	0.47	60	v [m/s]	h [m]	online
02_IP	MS_Igapark	-0.7067	60	v [m/s]	h [m]	online

Figure 1 : Location of the measuring points including representation of the measured parameters

$$load_{urban} = Q_{total} * C_{i,total} - Q_{rural} * C_{i,rural}$$

Q = discharge

C =concentration

1.2 Manuel reference measurement (sampling)

The continuous flow measurement (single beam ultrasonic) was calibrated by manual multipoint measurements, with focusing on the detection of high flow rates to minimize the error. The photometric measured values were verified on-site by a mobile laboratory and accordingly corrected by calibration curves. It was ensured that reference measurements were taken for the entire measuring range,

to avoid an extrapolation of calibration curves.

2. RESULTS AND DISCUSSION

2.1 Event oriented investigation

Figure 1 shows exemplarily a rain event with two peaks. Especially at the first peak the first flush effect is distinct. There is a strong increase of load at both measuring points for the parameters COD, TSS and NH3-N, this indicates that the impact of agricultural drainage systems and/or erosion is quite similar to urban rainwater discharges. It is interesting that, in contrast to the rural measuring point, oxygen is only introduced into the urban section by rainwater events. After each event, the oxygen curve steadily decreases in the urban section, probably due to degradation of introduced organic sediments. The COD load at the lower measuring point has a long trailing wave, although the TSS cargo quickly returns to its initial level. This may be explained by resolving COD from the sediment. Thus, in future measures for the implementation of the WFD, the improvement of the sole substrate should be focused for this stream.

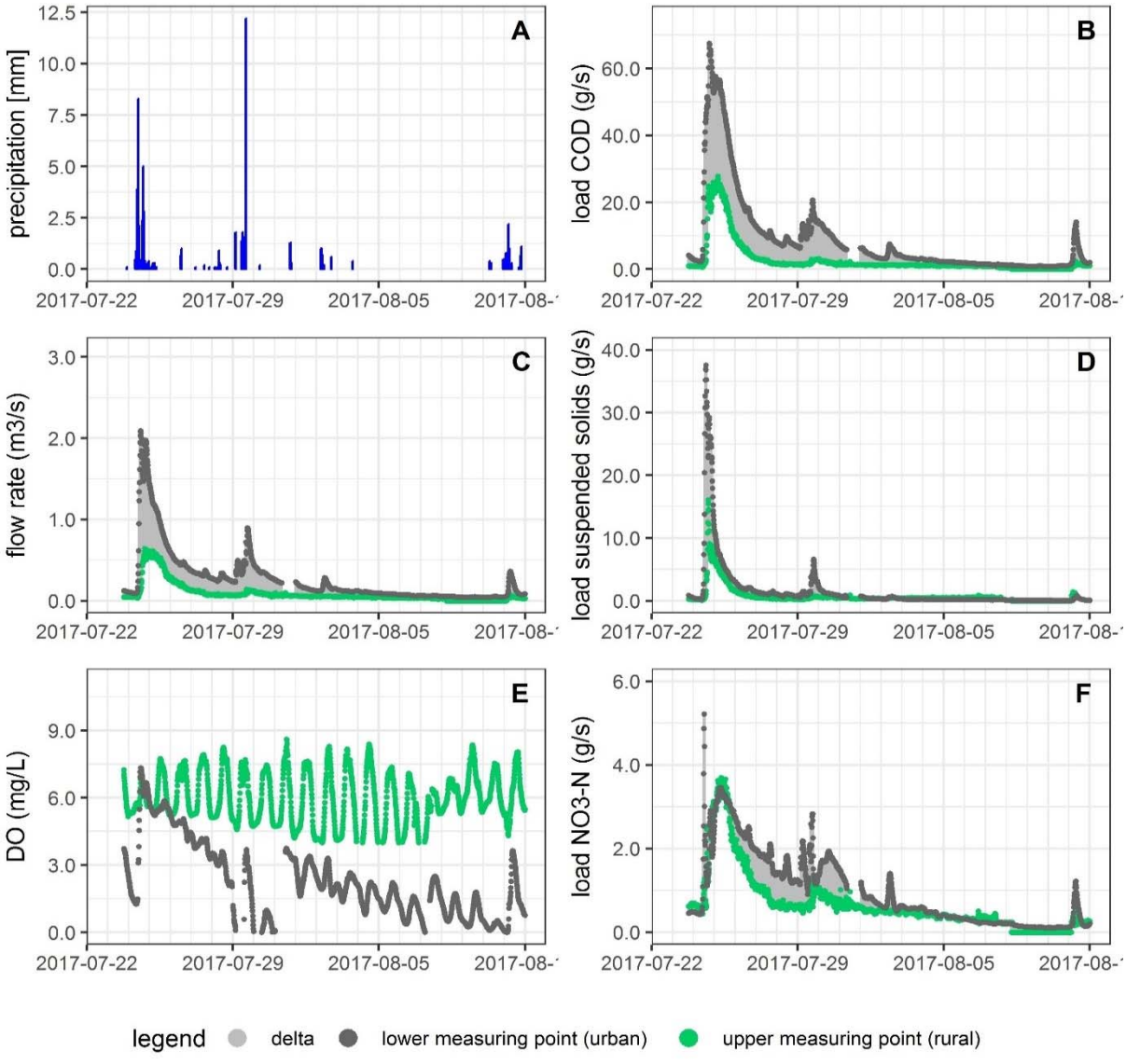


Figure 2 : Comparison of event-dependent concentrations and loads (Tränckner and Walter 2018)

2.2 Investigation with regard to the duration of the harmful effect

The toxicity of a water is primarily dependent on the pollutant concentration, where events with high concentrations and a short duration may be just as toxic as periods with long duration and lower concentrations (Schindler *et al.* 2010). Due to the temporally high-resolution concentration recording, it is not only possible to see whether a limit value is exceeded or undershot, but also how long a harmful situation lasts (Figure 3). It is assumed that the colonization by fish and macrozoobenthos due to the

oxygen depletion is sustainably limited (DWA 102).

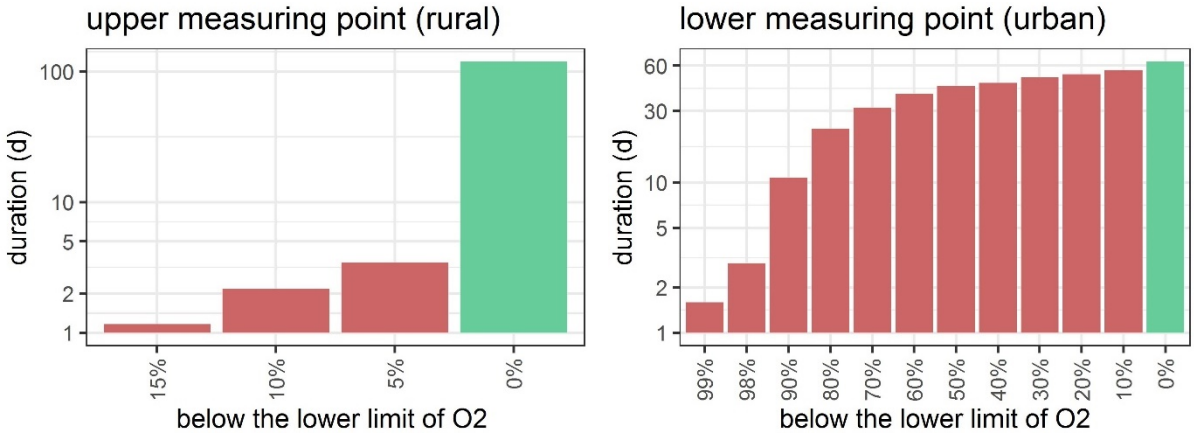


Figure 3 : Comparison of lack of oxygen with the duration of exposure

3. CONCLUSION:

Following issues can be highlighted:

- The load accounting in urban waters is characterized by various uncertainties. In particular, the flow measurement is characterized by an uncertainty of about ±10 % which has already been proven in other studies (Bertrand-Krajewski *et al.* 2003). Especially for shorter time spans or single events the balance can be disturbed by the sediment dynamics along the investigated river section (sedimentation, mobilization).
- By applying continuous monitoring, not only the pollutant concentration can be determined but also the duration of the harmful effects.
- Despite the above mentioned uncertainties, the impact of single events can be quantified. Also delayed effects as subsequent oxygen depletion become visible.
- The measuring system is completely automated, but the staff effort should not be underestimated. Maintenance and cleaning of the facilities had to be done in minimum once a week to avoid drift and the event-oriented measurement campaign required steady preparedness to perform reference measurements on heavy runoffs.
- The placement of the measuring points at the system boundaries is usually associated with increased human and financial resources. In this case flood protection, energy supply and protection against vandalism was a particular challenge.

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